Natural Conditions Assessment for Low Dissolved Oxygen, Fox Mill Run in Gloucester County, Virginia

Submitted by
Virginia Department of Environmental Quality

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Executive Summary

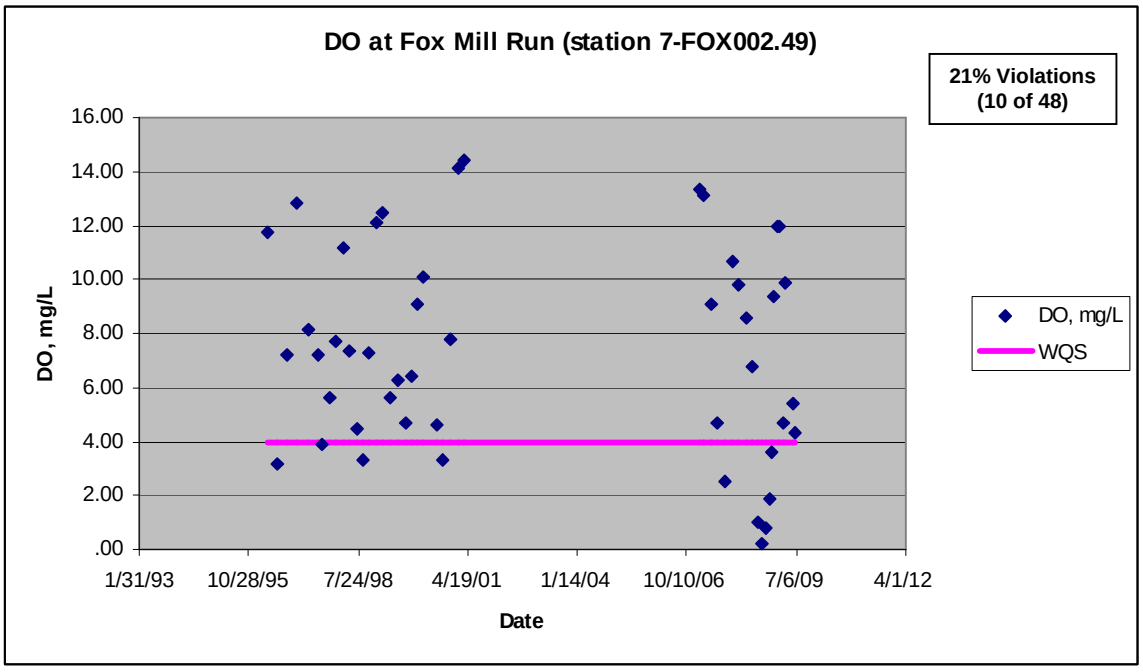
This report presents the assessment of whether low dissolved oxygen (DO) in Fox Mill Run and tributaries is due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Fox Mill Run and tributaries, including two unnamed tributaries to Fox Mill Run, and Crany Creek, located within Gloucester County, Virginia, are minor tributaries to the Ware River. The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal Fox Mill Run and tributaries is VAP-C05R. Fox Mill Run and tributaries encompass approximately 39.09 rivermiles (National Hydrography Dataset (NHD). Fox Mill Run was listed as impaired due to violations in water quality standards for DO. This report addresses the DO impairment.

The total area of the Fox Mill Run and tributaries watershed is approximately 15.64 square miles. The average annual rainfall is 46.28 inches. The watershed is approximately 10010 acres (15.64 mi^2) in size and is predominately forested (61.3 percent). Agriculture comprises 22.8 percent of the watershed, with 6.5 percent cropland and 16.3 percent pasture/hayland. Urban areas compose approximately 4.1 percent of the land base. The remaining 1.4 percent of the watershed is comprised of barren areas, and 10.5 percent wetlands and open water.

The mainstem of Fox Mill Run was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, and 2008 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, and 2008) due to violations of the State's water quality standard for DO. This report evaluates the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ monitored four stations on non-tidal Fox Mill Run and 4 stations on tributaries with dates ranging from April 1996 through June 2009. Of the 132 total DO data points recorded, 23 violated water quality standard for DO (17%), however 10 of 48 were concentrated at the original listing station 7-FOX002.49 (21%), which is shown in Figure E1.

Figure E1. Time series of DO at Fox Mill Run at Rt. 14/17, (station 7-FOX002.49).



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, the Fox Mill Run and tributaries must support all designated uses and meet all applicable criteria. If the waterbody violates the instantaneous DO water quality standard of 4.0 mg/l in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

In 2003 VADEQ proposed a methodology for determining whether low DO or pH originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia" (MapTech 2003).

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of swamps or wetlands. These conditions often also produce low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or low pH levels and for determining the likelihood of anthropogenic impacts is described below. DEQ staff use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure, all DO and pH data should be screened for flows less than the 7Q10. DO and pH data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

Fox Mill Run was estimated to be below 7Q10 during the period of August 10 – 28, 2008. On 8/25/2008 DO data on Fox Mill Run and tributaries showed four DO standard violations and four non-violations at flows below 7Q10. These DO violation data were removed from the Class VII Swampwater designation analysis. Removal of the four DO violations resulted in the UT to Fox Mill Run with station 7-XEF001.35 being removed from the impairment and percent violations being lowered on Fox Mill Run and Crany Creek.

The slopes of Fox Mill Run and Crany Creek were determined. The low slope for these streams ranged from 0.12% to 0.37%, which is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

Fox Mill Run exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

The Fox Mill Run and tributaries exhibit natural seasonal DO fluctuations due to the inverse relationship between water temperature and DO.

There are two active permitted (2 VAG) Point Source facilities in the Fox Mill Run and tributaries non-tidal watershed (C05R). These two sand and gravel facilities have no design flows or DO permit limits. These facilities are not expected to significantly impact DO.

Urban areas compose approximately 4.1 percent of the land base, most of which occurs near the original listing station. Agriculture makes up approximately 22.8 percent of the watershed. The watershed is predominately forested (61.3 percent), with 10.1 percent wetlands and 0.4 percent open water. The majority of the wetlands surround the mainstems of Fox Mill Run and Crany Creek. Land use was not considered to have significantly impacted the swampwater conditions of Fox Mill Run and its tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for mainstem Fox Mill Run and Crany Creek located in waterbody identification codes (WBID, Virginia Hydrologic Unit) C05R, from their headwaters to the head of tide on Fox Mill Run. If there is a 305(b)/303(d) assessment prior to the reclassification, Fox Mill Run and Crany Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Fox Mill Run tributaries low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Fox Mill Run and tributaries including three unnamed tributaries to Fox Mill Run and Crany Creek, located within Gloucester County, Virginia, are minor tributaries to the Ware River. Fox Mill Run and tributaries encompass approximately 39.09 rivermiles. Staff determined rivermiles from the USGS National Hydrography Dataset using GIS. Fox Mill Run and tributaries generally flow east from the headwaters near Sassafras, VA to the confluence with the Ware River east of Gloucester, VA. Fox Mill Run is tidally influenced from approximately river mile 1.99 downstream to the confluence with the Ware River. The tidal area is 0.0849 mi^2. The watershed totals approximately 15.64 mi^2. There is no continuous flow gaging station on Fox Mill Run.

2. Physical Settings

2.1. Listed Water Bodies

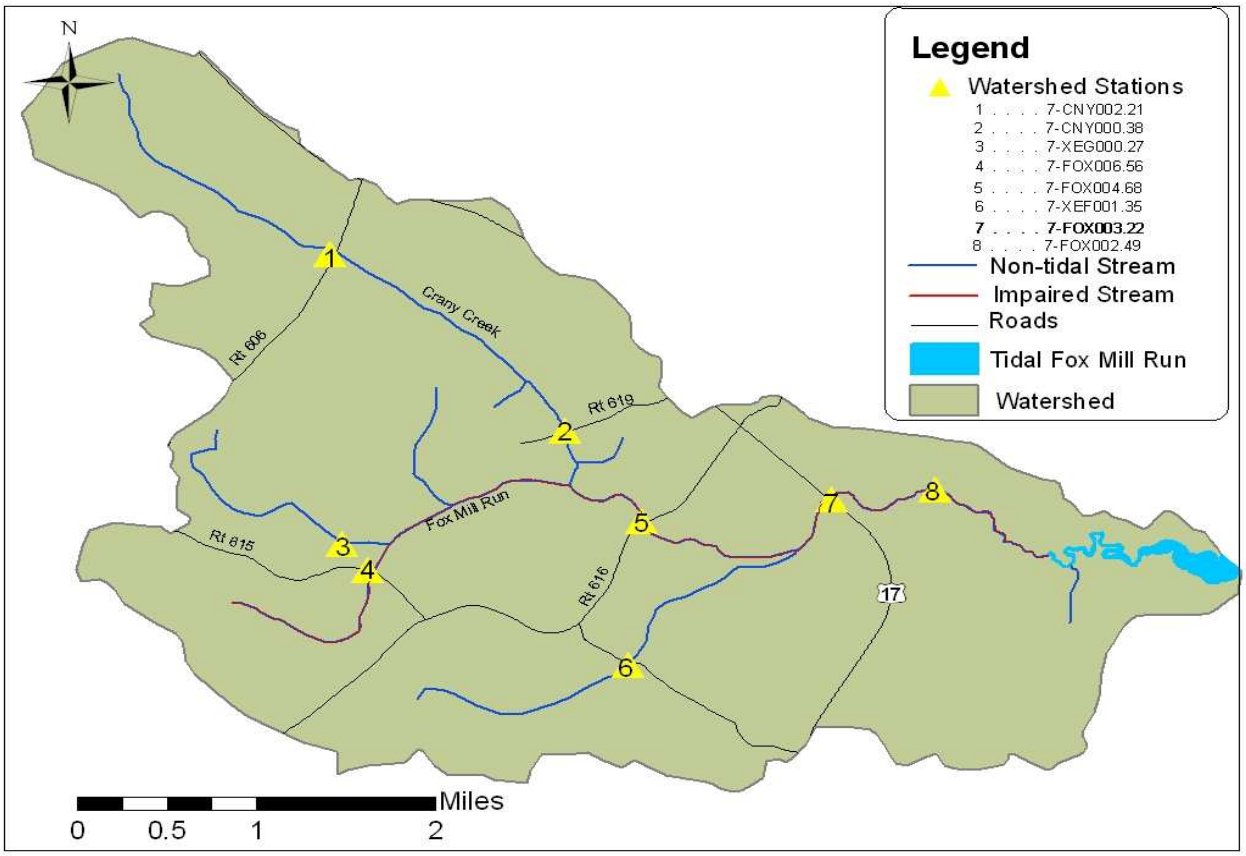
The mainstem of Fox Mill Run was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, and 2008 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, and 2008) due to violations of the State's water quality standard for DO. This report evaluates the DO impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal Fox Mill Run and tributaries is VAP-C05R.

2.2. Watershed

2.2.1. General Description

Fox Mill Run and tributaries flow east from the headwaters Sassafras and Ark, VA to the confluence of the Ware River southeast of Gloucester, VA. The total area of the watershed is approximately 15.64 square miles. See Figure 1 for a map of the watershed including monitoring stations.

Figure 1. The Fox Mill Run and tributaries watershed map and associated monitoring stations.



2.2.2. Geology, Climate, Land Use

Geology and Soils

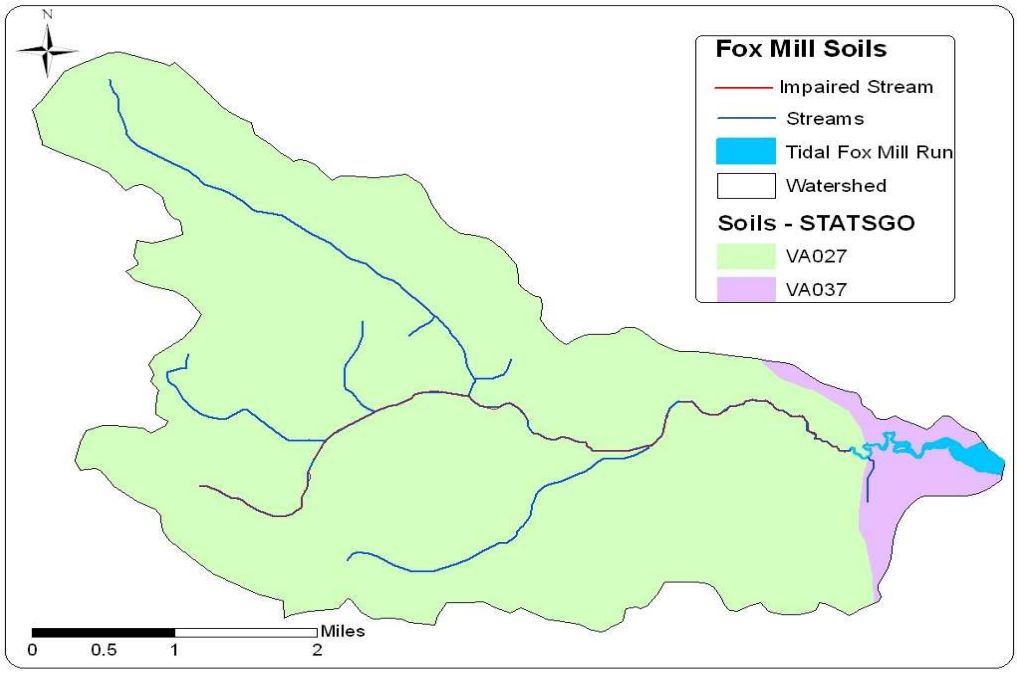
The impaired segments of the Fox Mill Run and tributaries are predominately within the Atlantic Coastal Plain physiographic region, though the headwaters of some tributaries are located within the lower Piedmont physiographic province. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf).

Soils for the Fox Mill Run watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://soils.usda.gov/technical/classification/osd/index.html). Figure 2 shows the location of these general soil types in the watershed.

Soils of the **Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027)** series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow permeability. They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

Soils of the **Bibb and Levy-Bohicket-Lumbee-Nansemond-Rumford-Tetotum-State-Suffolk (VA037)** Series are very deep to deep, and vary from well drained to very poorly drained. They range in slope from 0 – 15 percent. Their water capacity varies from low to high. This soils series was formed in sandy to loamy to mucky clay alluvial and marine sediments on the upper Coastal Plain and stream terraces.

Figure 2. Soil Characteristics of the Fox Mill Run Watershed.



Climate

The climate summary for the Fox Mill Run comes from a weather station located in Mathews 2 ENE, VA (445338) with a period of record from 1950 to 2000. The average annual maximum and minimum temperatures (°F) at the weather station are 68.1 and 48.2 and the annual rainfall (inches) is 46.28 (Table 1) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 1. Climate summary for Mathews 2 ENE, Virginia (445338).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	47.8	50.4	57.2	67.7	75.8	83.1	87.4	85.3	80.1	70.3	61.1	51.1	68.1
Average Min. Temperature (F)	28.9	31.0	36.5	45.7	55.0	63.5	68.8	67.0	61.3	49.9	39.9	31.4	48.2
Average Total Precipitation (in.)	3.54	3.61	4.54	3.26	3.85	3.67	4.30	5.44	3.80	3.80	3.10	3.36	46.28

Land Use

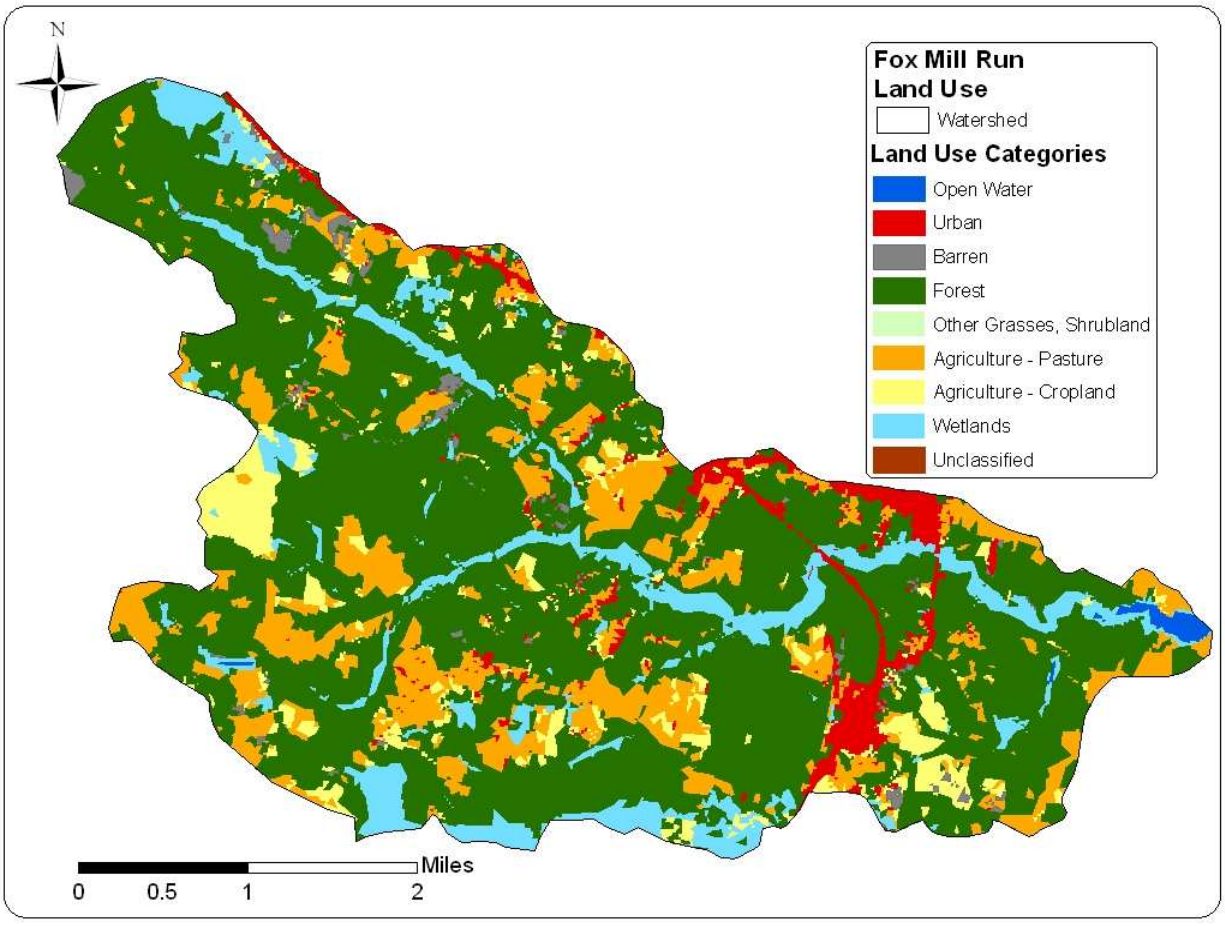
The Fox Mill Run and tributaries watershed extends approximately 5.5 miles from Sassafras to southeast of Gloucester, VA, and is 2 - 4 miles wide. The watershed is approximately 10010 acres (15.64 mi^2) in size and is predominately forested (61.3 percent). Agriculture comprises 22.8 percent of the watershed, with 6.5 percent cropland and 16.3 percent pasture/hayland. Urban areas compose approximately 4.1 percent of the land base. The remaining 1.4 percent of the watershed is comprised of barren areas, and 10.5 percent wetlands and open water. Land use is described in Table 2.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land use is concentrated along Rt. 17 and in the town of Gloucester, and wetlands / water land use is concentrated along the mainstem in the center and downstream portions to the mouth.

Table 2. Land Use in the Fox Mill Run and Tributaries Watershed

Land Use Type	Acres	Square Miles	Percent
Open Water	36.09	0.06	0.4%
Urban	410.21	0.64	4.1%
Barren	138.52	0.22	1.4%
Other Grass/Shrubland	0.00	0.00	0.0%
Forest	6132.67	9.58	61.3%
Agri - Pasture	1633.78	2.55	16.3%
Agri - Cropland	650.26	1.02	6.5%
Other Grass/Shrubland	0.00	0.00	0.0%
Wetland	1008.10	1.58	10.1%
Totals:	**10009.62**	**15.64**	**100.0%**

Figure 3. Land Use in the Fox Mill Run and Tributaries Watershed



3. Description of Water Quality Problem/Impairment

The mainstem of Fox Mill Run was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, and 2008 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, and 2008) due to violations of the State's water quality standard for DO. This report evaluates both the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

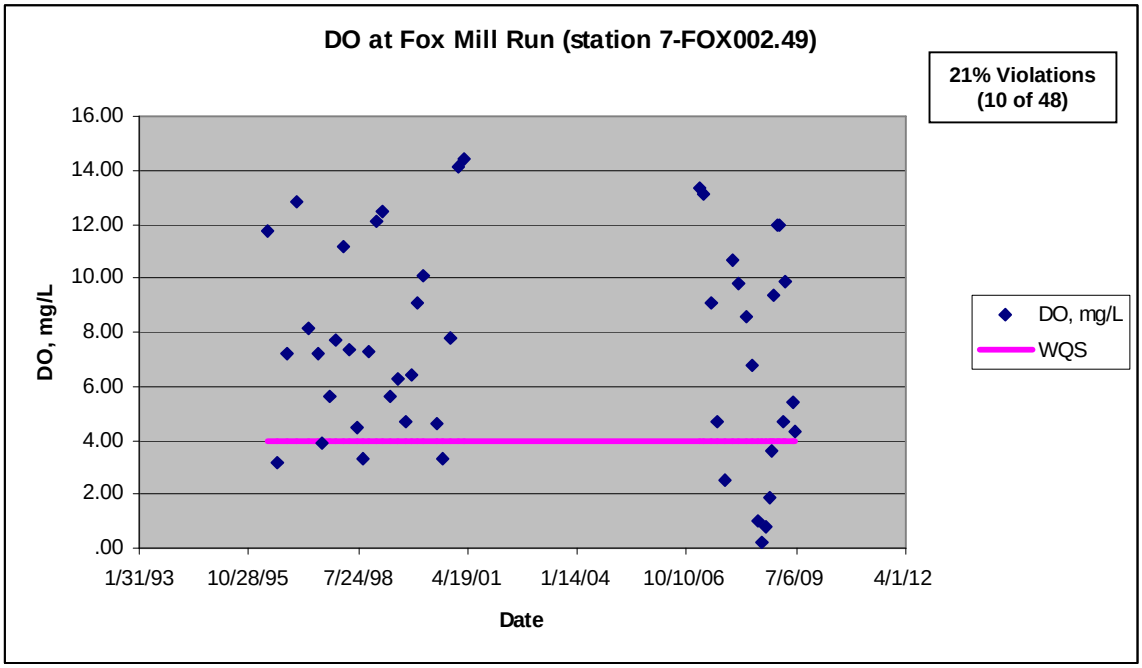
DEQ monitored 4 stations on non-tidal Fox Mill Run and 4 stations on tributaries (Figure 1) with dates ranging from April 1996 through June 2009. Of the 132 total DO data points recorded, 23 violated water quality standard for DO (17%), however 10 of 48 were concentrated at the listing station 7-FOX002.49 (21%) and 5 of 12 at station 7-CNY002.21 (42%) violated the water quality standard. The DO minimum and maximum values ranged from 0.2 to 14.4 mg/L. The results are summarized in Table 3.

Table 3. DO data collected by DEQ from 8 stations on Fox Mill Run and tributaries.

Station	Sample Period	n	Average DO	Min-Max DO	DO viol.	% Viol.
7-FOX002.49	4/10/1996 to 6/18/2009	48	7.4	0.2-14.4	10	21%
7-FOX003.22	7/23/2008 to 6/18/2009	12	7.9	3.7-12.3	1	8.3%
7-FOX004.68	7/23/2008 to 6/18/2009	12	8.4	0.5-12.7	1	8.3%
7-FOX006.56	7/23/2008 to 6/18/2009	12	6.3	1.9-10.1	3	25%
7-CNY000.38	7/23/2008 to 6/18/2009	12	7.0	3.7-11.8	1	8.3%
7-CNY002.21	7/23/2008 to 6/18/2009	12	5.6	0.4-11.0	5	42%
7-XEF001.35	7/23/2008 to 6/18/2009	12	6.9	0.2-12.3	2	17%
7-XEG000.27	7/23/2008 to 6/18/2009	12	8.9	7.3-10.7	0	0%

Time series graphs of all DO data collected at the original listing station, Fox Mill Run at Rt. 14, 7-FOX002.49, shows the DO ranging from 0.2 to 14.4 mg/L (Figure 4). The horizontal line at the DO = 4.0 mg/L mark represents the minimum water quality standard. The data points below the DO = 4.0 line illustrate violations of the water quality standard in Figure 4.

Figure 4. Time series of DO at Fox Mill Run at Rt. 14, (station 7-FOX002.49).



3.1 Associated DO Data of Fox Mill Run and Tributaries

DEQ also monitored DO data at 7 stations from further upstream on mainstem Fox Mill Run and 3 tributaries for the assessment of low DO due to the natural conditions. Associated stations with DO data are presented in Figures 5 - 11 below.

Figure 5. Time series of DO at Fox Mill Run at Rt. 17, (station 7-FOX003.22).

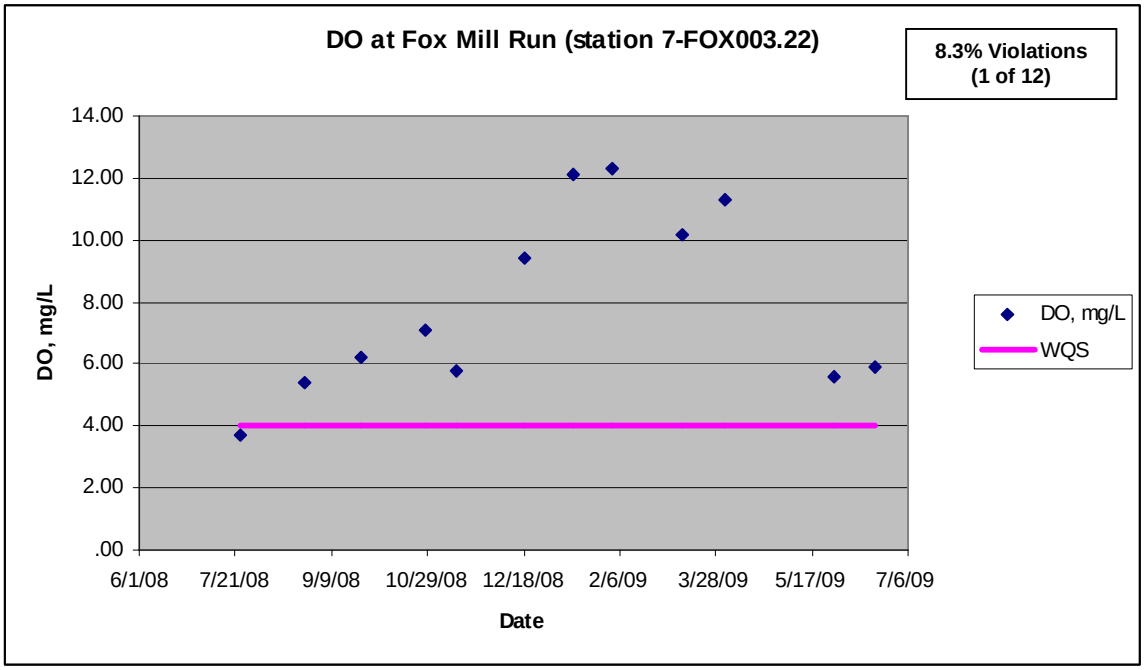


Figure 6. Time series of DO at Fox Mill Run at Rt. 616, (station 7-FOX004.68).

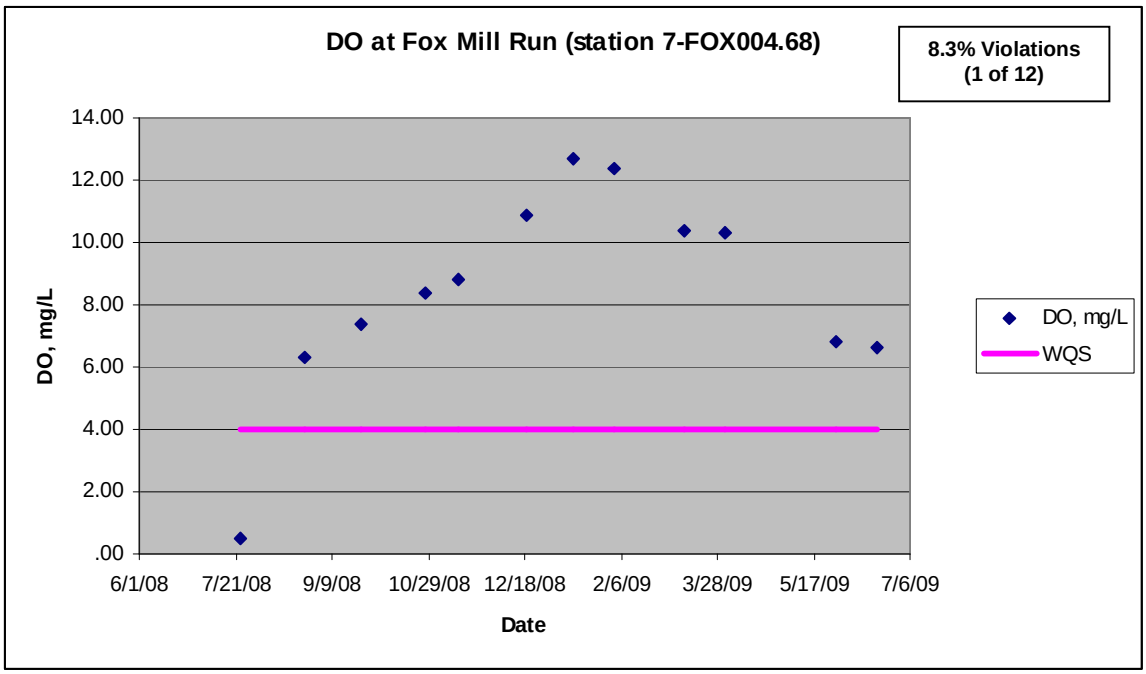


Figure 7. Time series of DO at Fox Mill Run at Rt. 615, (station 7-FOX006.56).

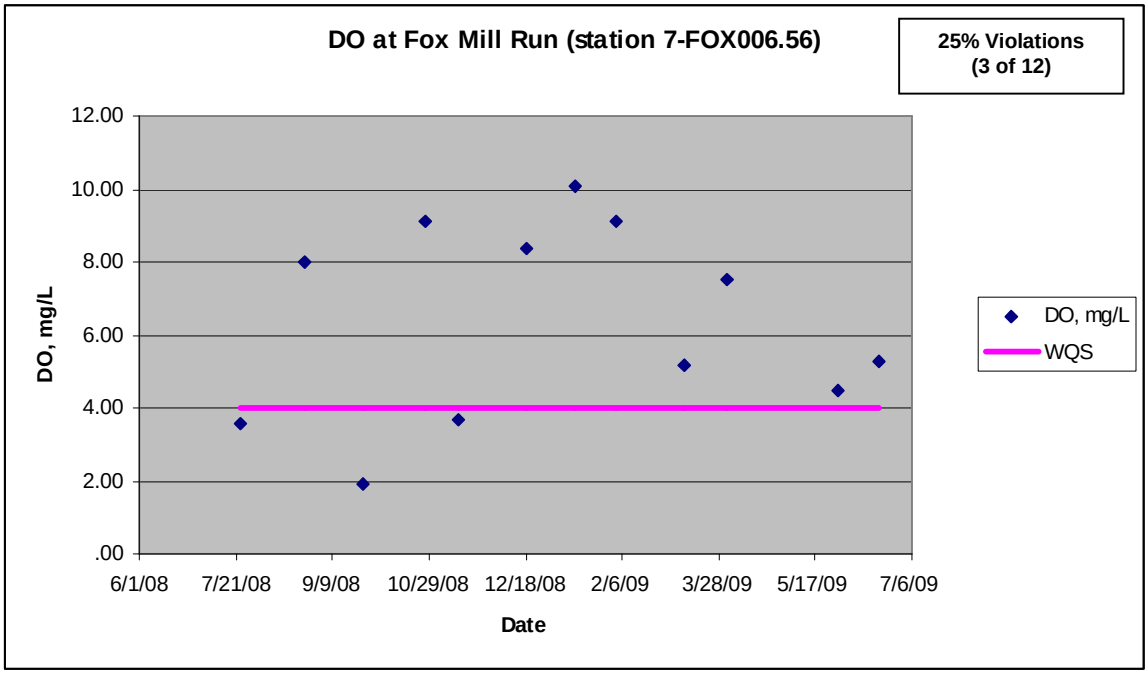


Figure 8. Time series of DO at Crany Creek at Rt. 619, (station 7-CNY000.38).

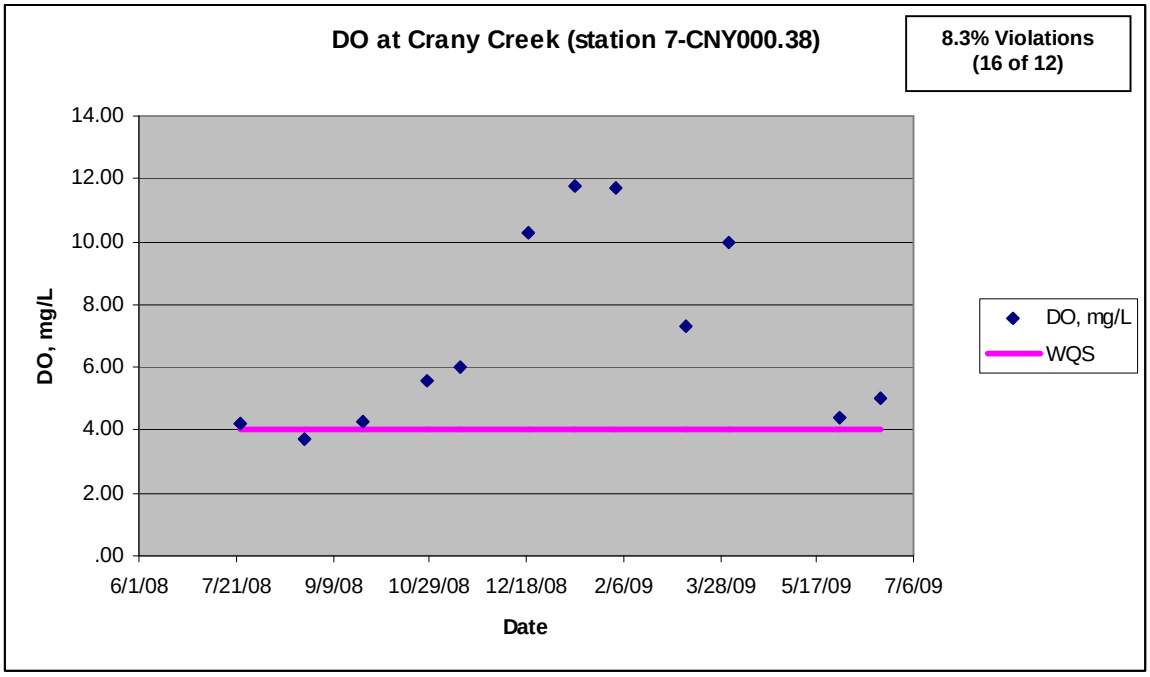


Figure 9. Time series of DO at Crany Creek at Rt. 606, (station 7-CNY002.21).

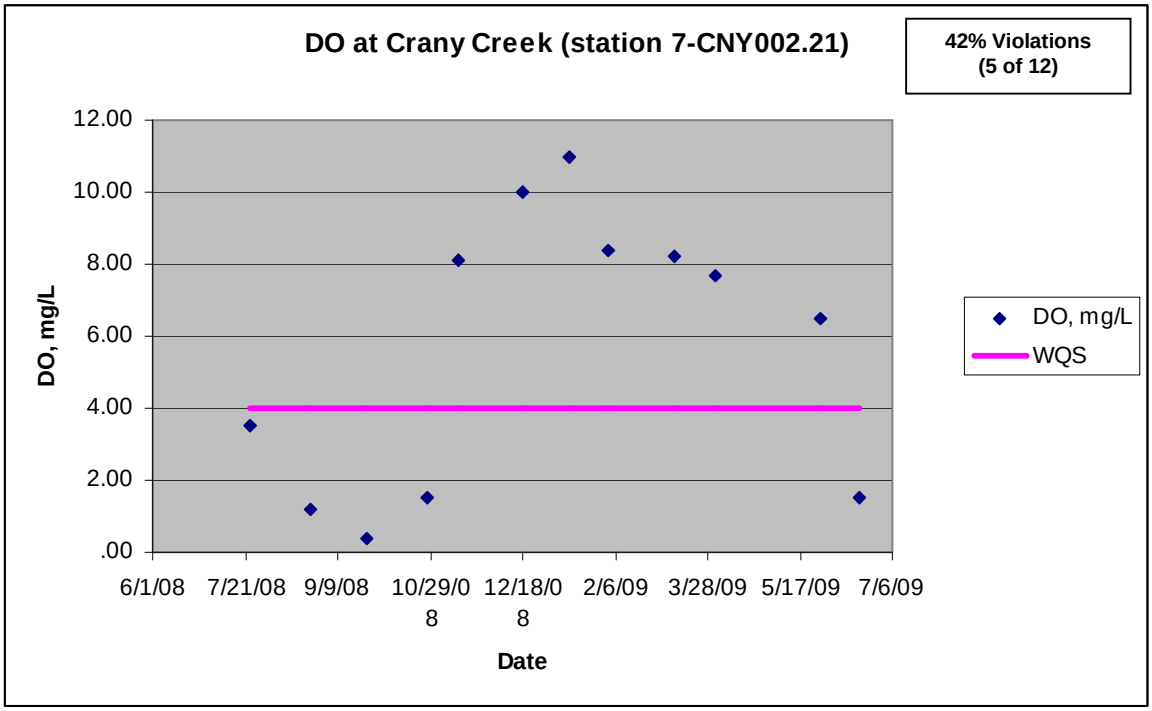


Figure 10. Time series of DO at UT to Fox Mill Run at Rt. 615, (station 7-XEF001.35).

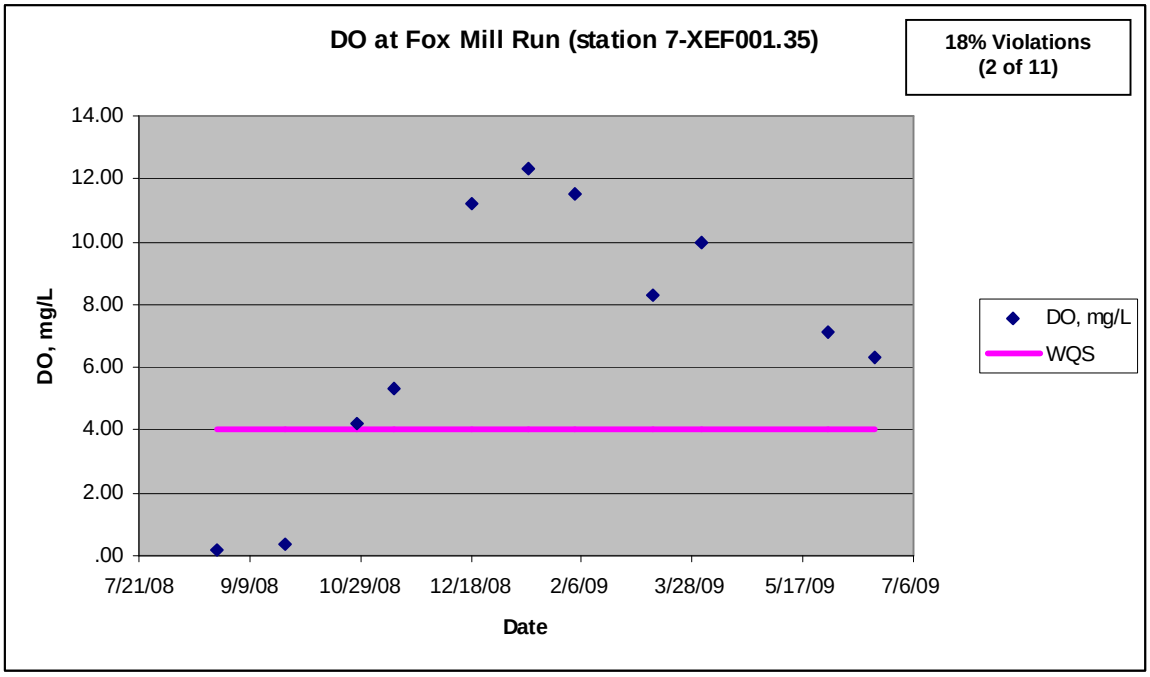
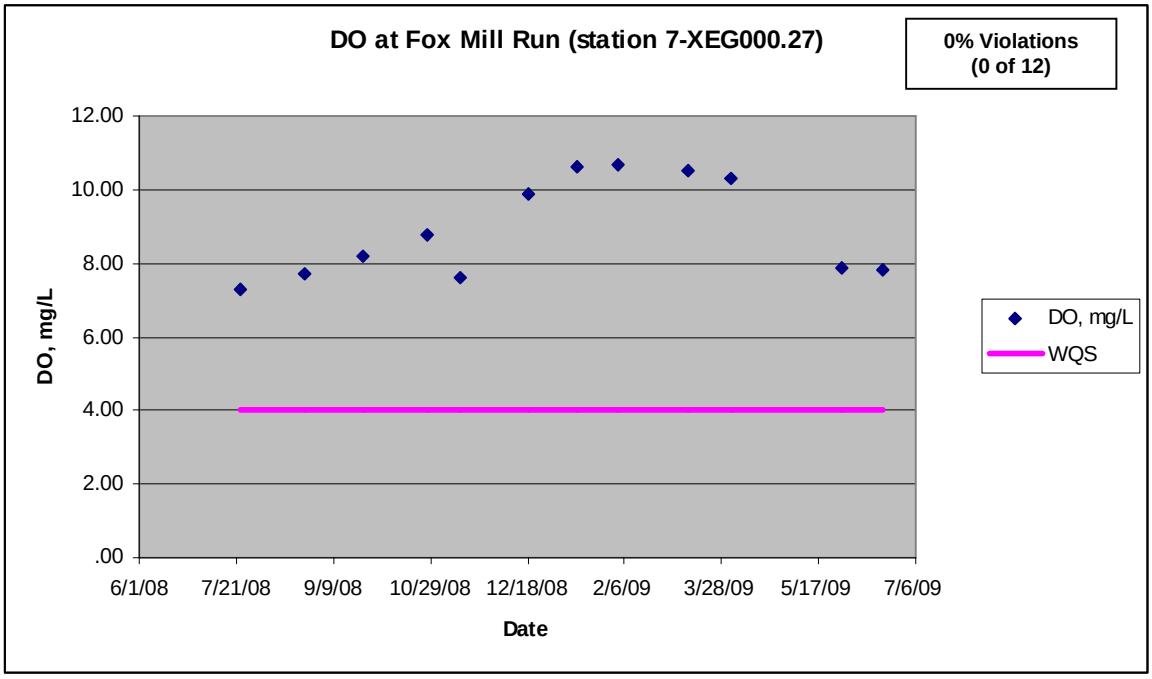


Figure 11. Time series of DO at UT to Fox Mill Run at Rosehill Road, (station 7-XEG000.27).



Four of eight stations monitored on Fox Mill Run and tributaries exceeded the water quality standards for DO in more than 10 percent of visits.

4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Fox Mill Run must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO and pH in the Fox Mill Run watershed are an instantaneous minimum DO of 4.0 mg/l and pH from 6.0 SU to 9.0 SU, as in Table 4.

Table 4. Applicable water quality standards

Parameter	Minimum, mg/l	Maximum, mg/l

DO	4.0	na

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data

analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy Rivers.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flow for Fox Mill Run and tributaries may be estimated by a drainage area ratio of the Fox Mill Run watershed (15.64 mi^2) with the 7Q10 flow at the long-term continuous gauging station Piscataway Creek near Tappahannock, VA, (USGS: 01669000), with a drainage area of 28.0 mi^2 and a 7Q10 of 0.50 cfs. Thus the 7Q10 of Fox Mill Run is estimated at 0.28 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

Fox Mill Run was estimated to be below 7Q10 during the period of August 10 – 28, 1008. On 8/25/2008 DO data on Fox Mill Run and tributaries showed four DO standard violations and four non-violations at flows below 7Q10. These DO violation data were removed from Class VII Swampwater designation analysis. The resulting percent violations are shown in Table 5 below. Removal of the four DO violations resulted in the UT to Fox Mill Run with station 7-XEF001.35 being removed from the impairment and percent violations being lowered on Fox Mill Run and Crany Creek.

Table 5. DO data collected by DEQ from 8 stations on Fox Mill Run and tributaries, with violations < 7Q10 removed.

Station	Sample Period	n-1 <7Q10	Average DO	Min-Max DO	DO viol.	% Viol.
7-FOX002.49	4/10/1996 to 6/18/2009	47	7.4	0.2-14.4	9	19%
7-FOX003.22	7/23/2008 to 6/18/2009	12	7.9	3.7-12.3	1	8.3%
7-FOX004.68	7/23/2008 to 6/18/2009	12	8.4	0.5-12.7	1	8.3%
7-FOX006.56	7/23/2008 to 6/18/2009	12	6.3	1.9-10.1	3	25%
7-CNY000.38	7/23/2008 to 6/18/2009	11	7.0	3.7-11.8	0	0%
7-CNY002.21	7/23/2008 to 6/18/2009	11	5.6	0.4-11.0	4	36%
7-XEF001.35	7/23/2008 to 6/18/2009	11	6.9	0.2-12.3	1	9.1%
7-XEG000.27	7/23/2008 to 6/18/2009	12	8.9	7.3-10.7	0	0%

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

The slopes of Fox Mill Run and Crany Creek were determined. The low slope for these streams ranged from 0.12% to 0.37% (Table 6), which is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

Table 6. Calculated percent slopes for Fox Mill Run and Tributaries.

Stream	% Slope	Upstream Elevation (Feet) at Rivermile (RM)	Downstream Elevation (Feet) at Rivermile (RM)
Fox Mill Run (total)	0.24	80’ at RM 8.33	0’ at RM 1.95
Fox Mill Run (lower)	0.12	10’ at RM 3.56	0’ at RM 1.95
Fox Mill Run (upper)	0.37	80’ at RM 8.33	30’ at RM 5.80
Crany Creek (total)	0.21	60’ at RM 3.17	20’ at RM -0.38 downstream on Fox Mill Run

Visual inspections of Fox Mill Run and tributaries revealed swampy areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers DO and pH as decay occurs. (Figures 12-15).

Figure 12. Fox Mill Run, Rt. 14/17 Business, 7-FOX002.49, Upstream.

Figure 13. Fox Mill Run at Rt. 615, 7-FOX006.56, Upstream.

Figure 14. Crany Creek, Rt. 619, 7-CNY000.38, Upstream.

Figure 15. Crany Creek, Rt. 606, 7-CNY002.21, Upstream.

5.3 Instream Nutrients

The VADEQ collected nutrient data from the original listing station 7-FOX002.49 (April 1996 to Nov. 2008, Table 7). Data points below the limit of detection were averaged using half the detection limit. The average nutrient concentrations are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO_3 + NO_2) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

Table 7. Instream Nutrients of Fox Mill Run at Rt. 14, 7-FOX002.49.

Parameter	Average Conc.	Number
Total Phosphorus	**0.075 mg/l**	(n=37)
Orthophosphorus	0.052 mg/l	(n=25)
Total Kjeldahl Nitrogen	0.556 mg/l	(n=25)
Ammonia as N	0.054 mg/l	(n=31)
Nitrate as N	**0.116 mg/l**	(n=25)
Nitrite as N	0.024 mg/l	(n=25)
TN (TKN + NO_3 + NO_2)	**0.668 mg/l**	(n=37)
Nitrite + Nitrate, Total as N	0.130 mg/l	(n=31)

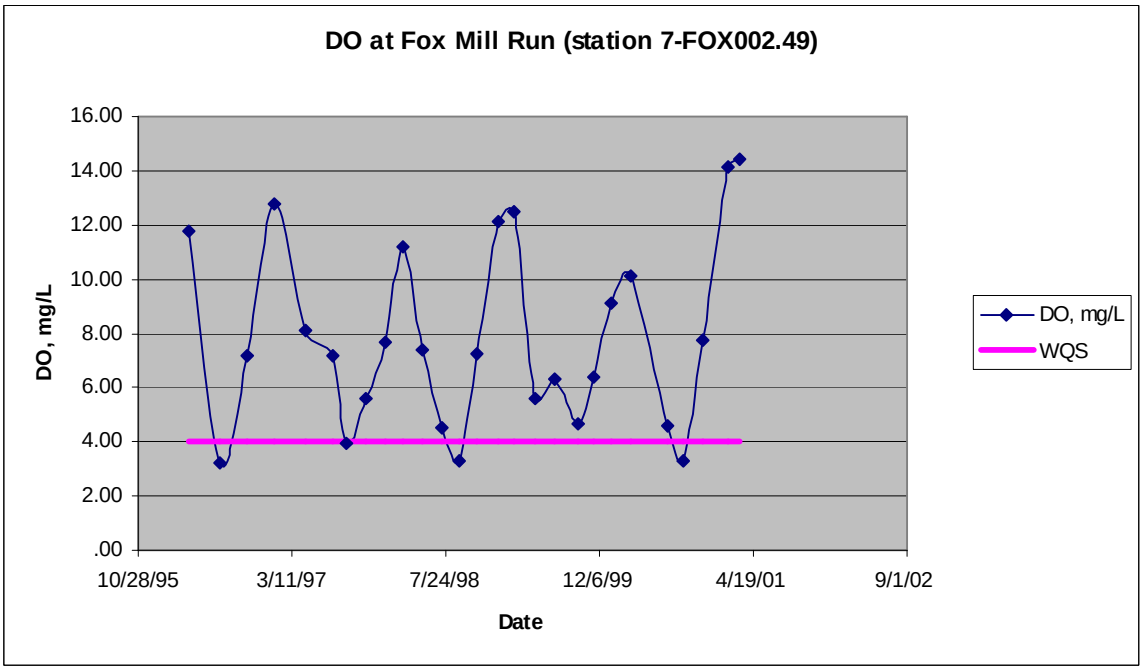
One outlier sample dated 11/3/1998 was removed from the nutrient dataset because all parameters were 10X higher than average except ammonia, which was 74 times higher than average. This one sample event caused all parameters to exceed the USGS background levels. This anomaly could not have come from the former Gloucester STP whose outfall was located 0.25 miles above the original listing station 7-FOX002.49 because the former plant was closed 6 years earlier in late 1992. From that time Gloucester influent was pumped to the Hampton Roads Sanitation District (HRSD) (Gloucester County Department of Public Works, personal communication 2010). An additional check of streamflow at the reference gage Piscataway Creek

near Tappahannock, VA showed no storm event on the previous 24 days, therefore it is unlikely that a storm event caused high stormwater runoff or a sewer system overflow on that date.

5.4 Natural Seasonal DO Fluctuation

The historical data collected at the Fox Mill Run original listing station 7-FOX002.49 were graphed to demonstrate the natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figures 16.

Figure 16. Seasonal DO Variation at Fox Mill Run at Rt. 14, April 1996 through March 2001.



5.5 Impact from Point Source Dischargers and Land Use

There are two active permitted (2 VAG) Point Source facilities in the Fox Mill Run and tributaries non-tidal watershed (C05R). The sand and gravel facilities have no design flow or DO permit limits, which are shown in Table 8. These facilities are not expected to significantly impact DO.

Table 8. Permitted dischargers with design flows and permit limits located within the Fox Mill Run tributaries watersheds.

Facility	Permit	Design Flow (MGD)	pH	DO (mg/L)	Receiving Stream
Mid-Atlantic Materials Inc – Hickory Hill Plant	VAG840171	N/A	6 - 9	N/A	Headwaters of Crany Creek
Coastal Design Sand Pit	VAG840163	N/A	6 - 9	N/A	Crany Creek

Urban areas compose approximately 4.1 percent of the land base, most of which occurs near the original listing station. Agriculture makes up approximately 22.8 percent of the watershed. The watershed is predominately forested (61.3 percent), with 10.1 percent wetlands and 0.4 percent open water. The majority of the wetlands surround the mainstems of Fox Mill Run and Crany Creek. Land use was not considered to have adversely impacted the swampwater conditions of Fox Mill Run and its tributaries.

6. CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

Fox Mill Run was estimated to be below 7Q10 during the period of August 10 – 28, 2008. On 8/25/2008 DO data on Fox Mill Run and tributaries showed four DO standard violations and four non-violations at flows below 7Q10. These DO violation data were removed from Class VII Swampwater designation analysis. Removal of the four DO violations resulted in the UT to Fox Mill Run with station 7-XEF001.35 being removed from the impairment and percent violations being lowered on Fox Mill Run and Crany Creek.

The slopes of Fox Mill Run and Crany Creek were determined. The low slope for these streams ranged from 0.12% to 0.37%, which is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

Fox Mill Run exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

The Fox Mill Run and tributaries exhibit natural seasonal DO fluctuations due to the inverse relationship between water temperature and DO.

There are two active permitted (2 VAG) Point Source facilities in the Fox Mill Run and tributaries non-tidal watershed (C05R). The sand and gravel facilities have no design flow or DO permit limits. These facilities are not expected to significantly impact DO.

Urban areas compose approximately 4.1 percent of the land base, most of which occurs near the original listing station. Agriculture makes up approximately 22.8 percent of the watershed. The watershed is predominately forested (61.3 percent), with 10.1 percent wetlands and 0.4 percent open water. The majority of the wetlands surround the mainstems of Fox Mill Run and Crany Creek. Land use was not considered to have significantly impacted the swampwater conditions of Fox Mill Run and its tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for mainstem Fox Mill Run and Crany Creek located in waterbody identification codes (WBID, Virginia Hydrologic Unit) C05R, from their headwaters

to the head of tide on Fox Mill Run. If there is a 305(b)/303(d) assessment prior to the reclassification, Fox Mill Run and Crany Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Fox Mill Run tributaries low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

7. References

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